A TREATISE ON SPINES.

A SERIES of papers upon "The Origin and Significance of Spines: a Study in Evolution," contributed by Dr. C. E. Beecher to the *American Journal of Science* from July to October last, has now been distributed by their author in a collected form. There are 80 pages in all, with 73 text illustrations, tables, and a plate delineating leading types of Radiolarian spines after Haeckel. Under the head of "spines" there are dealt with objects between and including "the modified hairs of the *Echidna* and Porcupine," and "the projecting rays and processes of Radiolaria"; movable and fixed forms are alike passed in review, horns and antlers come in for consideration, and only such "spines" appear to be disregarded as are "distinctly internal structures."

The author has been at immense pains to bring together all that is known concerning the nature, origin, laws of growth and limitations of spines, not excluding those met with in the vegetable kingdom; and while, in arranging in an orderly manner this vast accumulation of facts, he has done a good service, we venture to think that the utility of his essay is, to a large extent, marred by the too sudden diversion into side topics which at times appear to us irrelevant. The "law of variation," according to Cope; that of "multiplication of effects," according to Herbert Spencer; the principle of "localised stages of growth," by Jackson; of "reproductive divergence," by Vernon; with "sexual selection," and other supposed laws and heresies, are all in turn called in for comment and consideration. The author so flits about among extremes concerning both organs and doctrines under review, that the reader is often at a loss to discover his views and arguments, and at what he is sometimes aiming. Of all his theses, that which he seems to us to have best substantiated is expressed in his concluding remark that "after attaining the limit of spine differentiation spinose organisms leave no descendants, and . . . that out of spinose types no new types are developed." The subject of "spines" is a notoriously fascinating one upon which much has been written. On perusal of the excellent list of references which accompanies the papers, and comparison with the text, the author appears to us to have exercised too little discrimination in his reading, and to have been too prone to accept much which he found in print. Some of his allusions to the fishes and the desert plants appear especially open to this objection. His reputation is now so well established among working zoologists, in connection with his recent magnificent investigations into the phylogeny of the Brachiopoda and the structure and systematic position of the Trilobites—achievements of which even Yale College Museum may well be proud—that his present series of papers will be widely read. While we are profoundly thankful to him for having collected together and arranged in a workable form so instructive an amount of detail, we doubt if some of his conclusions will prove any more convincing to the majority than those which three years ago led him to a belief in the so-called Protaspis larva.

FOSSIL JELLY-FISH.

AN elaborate work on Fossil Medusæ, by Mr. C. D. Walcott, forms the thirtieth volume of the Monographs of the United States Geological Survey. The attention of the author was first directed to the occurrence of certain siliceous nodules, known as "star-cobbles," in the Middle Cambrian shales of Alabama; and after coming to the conclusion that these nodules contained fossil Medusæ, he was led to extend his researches to all the known fossil forms. Among these some had been recognised in Sweden by Nathorst, and in Bavaria by Haeckel; and the full record embraces forms from the Cambrian of the United States, Sweden, Russia, and Bohemia; from the Permian of Saxony; and from the Jurassic of Bavaria.

The author points out that, under certain conditions, when a Medusa is overwhelmed by muddy sediment, it may retain its shape sufficiently long for the sediment to solidify and make a mould of its external form. Plaster-casts of certain jelly-fish may in some instances be readily obtained. The most favourable conditions for the natural preservation of a Medusa appear to be by burial and rapid consolidation of sediment beneath water; but the author observes that not one in a hundred of the fossil specimens, shows traces of any structure within the body, and, so far as is known, the particularly favourable conditions required "were confined during geologic time to the vicinity of the spot in the Cambrian sea that is now occupied by the township of Cedar Bluff, Cherokee County, Alabama." There the nodules with Medusæ occur in finely laminated shales, and much of the silica forming the nodules appears to be original, and derived from the solution of siliceous organisms. The Medusæ lived in relatively shallow water, and were quickly overwhelmed and buried in a siliceous mud that was subsequently consolidated to form a siliceous shale. The silica, which forms a large portion of the shale, was probably derived from detrital quartz.

The author discusses the relation of the Medusæ to the Sponges, and more especially of the Middle Cambrian forms; and he then proceeds to describe the various species, which are illustrated in forty-seven plates. These figures will prove of considerable interest to geologists; they serve to draw attention to many curious and hitherto problematical structures; and may lead to more precise information with regard to their mode of occurrence. There appears to be no doubt that some of the forms, even of Cambrian age, are true Medusæ; and the author believes that at this early period, if not in pre-Cambrian times, the acraspedote Medusæ were mainly differentiated. He remarks, however, that we have yet much to learn about the medusiform ancestors of the Hydrozoa.

SEASONAL DIMORPHISM IN LEPIDOPTERA.[1]

I HAVE thought this to be a suitable subject for my address, because it is not only of high interest as a remarkable phase of variation, but has also of late years been brought prominently to notice by the researches of two groups of entomological observers; firstly, those who, like the pioneers, G. Dorfmeister, W. H. Edwards and August Weismann, have experimentally studied the effects of high and low temperatures artificially applied to lepidopterous pupæ of European or North American species; and secondly, those who have noted the seasonal changes in butterflies occurring naturally in various tropical and subtropical regions, and have in some cases reared one seasonal form of a species from ova deposited by the other. The earlier temperature experiments in Europe and North America were long in advance of the observations on seasonal dimorphism in tropical countries, the latter indeed being the natural outcome of the former. It may prove not uninteresting if I briefly pass under review the published memoirs relating to both sets of observations, but, as regards the temperature experiments, limiting my remarks almost exclusively to those relating to seasonally-dimorphic species.

No doubt many of us remember with what interest we welcomed Weismann's able treatise[2] published twenty-three years ago, whether in the original or in the English edition (translated by Prof. Meldola) issued in 1882. The cases known to Weismann, and described in this memoir, were not numerous; he calls special attention to six European cases (*Araschnia levana*, *Lycaena amyntas*, *L. agestis*, *Chrysophanus phlaeas*, *Pieris napi*, and *Euchloe belia*), and to three North American (*Phyciodes tharos*, *Grapta interrogationis* and *Papilio ajax*), the latter known to science through the investigations of W. H. Edwards, the well-known monographer of the butterflies of North America, whose experiments and results[3] are republished with additions as Appendix II. to Weismann's essay. In the phenomenon of seasonal dimorphism Weismann recognised, as two prominent factors in the possible *direct* influence of the varying external conditions of life, temperature and duration of the pupal period; and his experiments with *Araschnia levana* and *Pieris napi* were accordingly carried on with the view of ascertaining whether the dimorphism exhibited by those species could be traced to the direct action of those factors. In the case of *A. levana*, he first subjected the pupæ obtained from eggs laid by the winter form, immediately after pupation, to artificial low temperatures, and the result was that, by exposure to temperature of 0°–1° R. for four weeks, threefourths of the pupæ produced, not the summer form *prorsa*—as under natural conditions they would have done—but the intermediate form *porima* (extremely rare in nature), three of these being very nearly the pure winter form *levana*. Increasing the period of exposure to cold to eight weeks did not materially add to the extent to which the summer form was lost and the winter form substituted. The converse experiment, frequently repeated, consisted in placing in a hot-house (temperature 12°–24° R.) immediately after pupation, pupæ from eggs laid by the August brood of the summer form, *prorsa;* but here the artificial temperature had little or no effect, all, or nearly all, the pupæ hibernating, and emerging in the following spring as the pure winter-form *levana*. This latter result led the author to the opinion that cold and warmth could not be the *immediate* causes of a pupa emerging in the *prorsa* or *levana* form; and that the explanation of the facts seemed to be (*a*) that the winter form *levana* is the original type of the species, seeing that it was found possible to make many specimens of the summer form *prorsa* revert to it by means of cold, whereas the converse change could not be effected; and (*b*) that the species originally existed in the glacial period as a single-brooded and monomorphic butterfly, and only became double-brooded and gradually developed the *prorsa* form as warmth of climate increased.

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[1] An address read before the Entomological Society of London at the annual meeting on January 18, by Roland Trimen, F.R.S., President of the Society.

[2] "Studien zur Descendenz-Theorie. I. Ueber den Saison-Dimorphismus der Schmetterlinge," 1875.

[3] *Canadian Entomologist*, vii. p. 236 (1875), and ix. p. 69 (1879).

With *Pieris napi*, Weismann found the pupæ from eggs laid by the winter form much more responsive to the action of cold (applied immediately after pupation and continued for three months) than those of *A. levana*, by far the larger number emerging as the pure winter form when transferred to a hot-house, and the remainder (which resisted forcing and hibernated) all producing the same form in the following spring. The converse experiment was not tried with the pupæ of ordinary *P. napi*, but with those of the Alpine and Polar variety, *bryoniae*, but the result was in accordance with that of the corresponding experiment in the case of *A. levana*—the application of heat had no transforming effect, and all the butterflies emerged as pure *bryoniae*. Weismann was thus led to regard the single-brooded variety *bryoniae* as the original form of the species from the glacial period, and *napi* in its winter and summer forms as gradually produced under increasing climatic warmth.

The experiments conducted with so much skill and perseverance by W. H. Edwards with the North-American *Papilio ajax* and *Phyciodes tharos* yielded much the same results as those obtained by Weismann in Europe. In the complicated case of *P. ajax*—where the winter form presents itself in the two differing generations known as *walshii* and *telamonides*, and the summer form known as *marcellus* appears in three similar generations—Mr. Edwards, by the application of ice for a period of two months, found that fifty pupæ reared from eggs laid by the second generation of the winter form (*telamonides*), which under natural conditions would nearly all have given the summer form *marcellus*, produced no fewer than twenty-two *telamonides*, one specimen intermediate between *telamonides* and *walshii*, eight examples intermediate between *telamonides* and *marcellus*, but nearer to the former, eight intermediate between the same forms but nearer to the latter, and only eleven true *marcellus*. It should be observed, however, that there is a difference in the shape of the wings between the winter and summer forms of this *Papilio*, and that the strong innate tendency of the progeny of the winter form to assume the summer form was evidenced in the fact that all the butterflies from the refrigerated pupæ which had the markings of *telamonides* or of *walshii* yet bore the shape of *marcellus*.

The extreme variability of *Phyciodes tharos* renders it difficult to follow the details of Edwards' experiments with the various broods from different districts, but it is clear that, as in the case of *P. ajax*, the application of cold induced the summer form to revert to the winter form (*marcia*). I do not gather that the converse experiment was tried with this butterfly; but it was attempted to a certain extent with *Papilio ajax*, whose hibernating pupæ were subjected to a moderate degree of heat during some months, for several years in succession, without any change being effected in the resulting winter form of the butterfly. The evidence in the case of *Grapta interrogationis* has a different bearing on the subject, seeing that this species does not hibernate as pupa but as imago, and that therefore there is not, strictly speaking, any "winter" form; but it would appear that the first of the four broods in the year consists wholly of the form named *umbrosa* and the fourth of the form named *fabricii*, while the intervening second and third broods are each composed of both forms.

Only brief reference is made by Weismann to the experiments on *Araschnia levana* made by G. Dorfmeister,[1] an account of which was published as far back as 1864, but a full *résumé* of them has been given by the late Prof. Th. Eimer.[2] From this I find that, although, as Weismann points out, Dorfmeister did not succeed—apparently from not employing a low enough temperature—in transforming the *prorsa*-form into the *levana*-form, but obtained only some few of the intermediate form *porima*, yet he was apparently repeatedly successful in the important converse experiment (where Weismann's results were almost negative), obtaining *prorsa* by means of warmth from the *prorsa* August brood. He further obtained numerous gradations of the intermediate form *porima*, stages which under natural conditions occcur so rarely that, during forty years' collecting, he met with only a single specimen in the wild state in places where the forms *levana* and *prorsa* were quite common. Dorfmeister was clearly the first to point out that temperature exercises its chief influence during the act of pupation or shortly afterwards, but he expressed his "inability to decide whether the modifications obtained were the direct consequence of the rise in temperature, or only the indirect, depending on the shortening of the time of development caused by the increased temperature."

Familiar to all of us is the fine series of papers on temperature experiments contributed to our *Transactions* and *Proceedings*, to the *Entomologist*, and to the *Proceedings* of the South London Entomological Society by our Secretary, Mr. F. Merrifield; they are eight in number, the first having been published in 1888 and the last in 1897.[3] Mr. Merrifield's earlier experiments were made with Geometrid moths of the genera *Selenia* and *Ennomos*, certain species of which have normally two differing seasonal forms in England, and they extended to the application of both icing and forcing for various periods in all stages from egg to imago. The results were of much interest from many points of view, and more especially as showing (*a*) that the continued application of low temperature to the pupæ reared from eggs laid by the spring brood produced moths more and more like their parents, instead of the natural summer form; (*b*) that the opposite experiment of applying heat to the pupæ from eggs of the summer brood was fatal to a majority of individuals, and produced in the survivors a proportion of the summer form but mainly specimens intermediate only between the spring and summer types; (*c*) that it was in the pupal state that temperatures exercised their chief influence; (*d*) that forcing produced pale and comparatively spotless moths, while cooling or icing produced dark and much spotted ones. Another noteworthy point was that the application of *moisture* in combination with various temperatures to the pupæ of *S. tetralunaria* and *E. autumnaria* had no effect on the resulting moths.

The dimorphic species next treated by Mr. Merrifield in 1892–93 were *Pieris napi*, *Araschnia levana*, and *Chrysophanus phlaeas*. The results in the first and second of these species were generally confirmatory of those obtained by previous experimenters. In the case of *C. phlaeas*, which, though many-brooded almost throughout its immense range, does not exhibit seasonal dimorphism in Europe except in Southern Italy, Corsica and Greece, forcing caused on the upper side the dusky suffusion and larger black spots of the forewings characteristic of the southern summer form *eleus*, while cold induced exactly the opposite characters in the forewings, and also a great broadening and radiation of the coppery band in the hindwings. In 1896, Mr. Merrifield experimented on pupæ of *Pieris daplidice*, and found that forcing produced the ordinary summer form, while cooling for six weeks brought out the spring form *bellidice*.

I have here only very briefly mentioned those of Mr. Merrifield's experiments which dealt with seasonally-dimorphic species. His researches extended besides to upwards of twenty monomorphic ones; they were carried out with admirable skill, care, and exactness of record, and the resulting phenomena—especially in the species of *Vanessa*—were not only most remarkable in themselves, but also, as disclosing apparently ancestral characters, of the deepest interest in their bearing on the phylogeny of the species concerned. The latter aspect of these investigations has been ably dealt with by Dr. F. A. Dixey, who, in his published comments on Mr. Merrifield's papers of 1893 and 1894,[1] points out that they seem to go far towards indicating the possibility that a disturbance of natural temperature conditions, whether in the direction of heat or cold, can produce in a monomorphic species a tendency towards reversion, and also notes the production by these experiments of ancestral features in *Vanessa io*, *V. polychloros*, and *Grapta C.-album.*

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[1] "Ueber der Einwirkung verschiedener während der Entwickelungsperioden angewendeter Wärmegrade auf das Farbung und Zeichnung der Schmetterlinge." (*Mittheil. Naturw. Vereins für Steiermark*, 1864.)

[2] "Entstehung der Arten auf Grund von Vererben erworbene Eigenschaften nach der Gesetzen organischer Wächsens," 1888. (Engl. transl., by J. T. Cunningham, 1890, Sect. iv. pp. 131–134. I have to thank Mr. Merrifield for lending me this work.)

[3] For a most convenient *précis* and illustration of Mr. Merrifield's work, by Dr. F. A. Dixey, see NATURE, vol. lvii. pp. 184–188 (1897)

Concurrently with Mr. Merrifield's later work appeared both Dr. M. Standfuss's[2] and Prof. Weismann's[3] important memoirs, containing accounts of the series of temperature experiments carried on by them respectively in the course of the last decade. Standfuss's paper of 1894 deals with the effects of the warm and cold treatment of the summer pupæ of nine species of European butterflies. None of these can be included among seasonally-dimorphic species in Europe itself, but the author points out that the effect of heat on the Zürich pupæ of *Papilio machaon* was to produce specimens perfectly resembling the August form of the species that is found in Syria. Other striking results as given by the experimenter were the production of specimens representing (*a*) Local forms, such as constantly occur in nature in certain definite localities; in *Vanessa urticae*, *Pyrameis cardui*, and to some extent in *Papilio machaon* and *Vanessa antiopa:* (*b*) Aberrations, like those which now occur in nature; in *V. io*, *P. cardui*, and *Argynnis aglaia:* (*c*) Phylogenetic forms, "which may have either existed in past epochs, or may perhaps be destined to arise in future": in certain cooled *V. io* and *V. antiopa* and certain warmed *V. atalanta*, and the reverse respectively. Noting the remarkable circumstance that the same conditions lead to such diverse effects in different species—the changes wrought in one species being entirely within the limits of its variation at the present day, while in another they far surpass those limits—he suggests that the species coming under the former category are the phylogenetically older, and those belonging to the latter are the phylogenetically younger. The author found that the high temperature of 104° F. rapidly caused death in nearly all the species tested—*P. machaon* and *G. C.-album* proving least sensitive—but low temperatures prolonged for even four weeks are much better tolerated; and it was thought that this favoured the conclusion that the species so tested "were constrained in past ages to accommodate themselves much more to lower than to higher temperatures."

In the edition of his "Handbuch," which appeared in 1896, Standfuss recapitulated the cases published in 1894, and added mention of a warmth experiment with *Gonepteryx rhamni* which had the effect of inducing in the females some indications of the yellow colouring of the males. He also gave excellent coloured figures of most of the more marked variations resulting from temperature treatment, some of them exhibiting marvellous divergence from the normal form now existing in nature.

Before turning to Weismann's memoir of 1895, it will be convenient to refer briefly to Standfuss's recent and elaborate treatise issued during 1898.[4] After reviewing (in Sect. I.) his experiments as to effects from treatment of pupæ with constant moderately high (+ 37° to + 39° C.) or moderately low (+ 4° to + 6° C.) temperatures in the years from 1885 to the beginning of 1895, the author proceeds (in Sect. II.) to give an account of the continuation of these "Warm and Cold" experiments during the succeeding period from the middle of 1895 to 1897. These additional experiments were made on no fewer than fifty-six species of European Lepidoptera (thirty-six butterflies and twenty moths), and on a largely-increased number of specimens; and their results were found to be fully confirmatory of those derived from the earlier more restricted experiments, affording various fresh instances of the production of more or less marked variation in the directions previously indicated, viz. seasonal forms, local forms, aberrations, phylogenetic forms, and forms showing assumption of the male colouring by the female. Under the respective headings of "Frost-Experiments" (Sect. III.) and "Heat-Experiments" (Sect. IV.), the several results are given of employing temperatures under 0° C. (0° to – 18° C., and exceptionally to – 20° C.), and those above + 40° C. (up to + 45° C.); and the attempt is made (Sect. V.) to explain from the results of these two sets of experiments the active cause of most of the "Aberrations" occurring in nature. Attention is directed to the extremely interesting fact that the aberrations resulting from the artificial very high temperatures agree closely with the aberrations found in nature,[1] while aberrations like those produced by the use of very low temperatures are never found in nature; and the inference drawn from this is that the typical aberrations occurring naturally among the Nymphlidæ are produced by the temporary influence on a high degree of heat (40° to 45° C.).

I cannot here do more than just refer to the remaining sections of Dr. Standfuss's treatise; they include a consideration of the mode of action of the frost and heat experiments, a discussion as to the nature of aberrations, and an account of the further breeding of aberrational *Vanessa urticae*, and with the concluding remarks at pp. 37 and 38 will well repay perusal. Some idea of the satisfactory and extensive scale upon which the experiments were conducted, may be gathered from Standfuss's statement that he had employed altogether during 1895–97 the number of over 42,000 pupæ belonging to about sixty different species.[2]

Weismann's memoir of 1895, above referred to, contains a full record of his later experiments and results in the cases of *Araschnia levana*, *Chrysophanus phlaeas*, and *Pieris napi*, as well as in those of *Pararge egeria* (with its "climatic variety," *meione*) and *Vanessa urticae.* It further treats of the effect on pupæ of variously-coloured light, and on hibernating pupæ of warmth, and concludes with a comprehensive general review of the whole subject, including a comparison of the results of some of his own experiments with those obtained by Merrifield and Standfuss. In the case of *A. levana*, he not only succeeded, by means of temperatures of 27–28° C. and 30-32° C., in obtaining repeatedly a small number of the *prorsa*-form from the second summer generation of that form, but also proved that occasionally the same result arose in isolated instances without the use of a higher temperature than that of an ordinary warm room. It was further established that the intermediate forms known as *porima*, so rare under natural conditions, are produced whenever a brood is subjected to an unsuitable temperature at the beginning of the pupal stage, occurring indeed with the second brood from unusual cold, and with the third brood from unusual heat. As regards the seasonal forms of *Pieris napi*, it was shown that the low temperature effects the conversion of the summer form into the winter, only when specially applied immediately after pupation; while repeated experiments with the variety *bryoniae* gave no sufficient support to Weismann's view that this variety was the original parent-form of *napi*.

It is in this memoir that Weismann first recognises fully what he had formerly questioned, but had latterly ("Aeussere Einflüsse als Entwickelungsreize," 1894), put forward as probable, viz. that, besides the direct seasonal dimorphism attributable to temperature, there also exists *adaptive* seasonal dimorphism dependent on the indirect influence of the varying environment according to the time of year. He again cites the case of *A. levana* itself as possibly exhibiting in its *prorsa*-form mimicry of *Limenitis*, and suggests that the seasonal forms of *P. napi* may be adapted on the underside to the vegetation tints of spring and summer respectively. In the case of the latter species he expresses the belief that adaptive and direct seasonal dimorphism are combined, pointing out that the differences presented by the upperside may perhaps be referred to the direct influence of temperature. The possible adaptation of the green-and-white underside of the dimorphic *Anthocharis belia* to the respective resting plants of each season is also indicated.

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[1] See Dr. Dixey's papers (1) "On the Phylogenetic Significance of the Variations produced by difference of Temperature in *Vanessa atalanta*" (*Trans. Ent. Soc. Lond.*, 1893, p. 69); and (2) "Mr. Merrifield's Experiments in Temperature Variation as bearing on Theories of Heredity." (*Op. cit.*, 1894, p. 439.)

[2] "Ueber die Grunde der Variation und Aberration des Falterstadiums bei den Schmetterlingen," 1894. (Engl. transl. by Dr. F. A. Dixey in *Entomologist*, 1895.) "Handbuch der Paläarktischen Gross-Schmetterlinge für Forscher und Sammler," 1896.

[3] "New Experiments on the Seasonal Dimorphism of Lepidoptera" 1895). Engl. transl. by W. E. Nicholson in *Entomologist*, 1896.

[4] "Experimentelle Zoologische Studien mit Lepidoptern. A. Temperatur-Experimente." (*Denkschr. Schweiz. Naturf-Gesellsch.*, xxxvi. i. 1898.)

[1] This is well illustrated by Plate IV. accompanying the memoir, where figures of Aberrations, (*a*) captured at large, and (*b*) forced at very high temperature, of the following species, are given side by side, viz. *Vanessa polychloros*, *V. antiopa*, *V. atalanta*, and *Pyrameis cardui*, Figs. 1, 3, 5, 7 differing very slightly respectively from Figs. 2, 4, 6, and 8. (Plate III. figures the Aberrations produced in the same four species by "Frost-Experiments.")

[2] Dr. E. Fischer, of Zürich, has also carried out very extensive temperature experiments on European Lepidoptera with most striking results, which are mentioned by Weismann, Merrifield, and Standfuss. I have not seen Dr. Fischer's published accounts of his work, but I believe he did not experiment with seasonally dimorphic species.

The poverty, however, of such instances among the seasonally dimorphic species of the European butterfly-fauna is manifest; and it is thus satisfactory to find Weismann turning, in support of his view, to the numerous striking cases (first brought to his notice in 1894 in a paper by Dr. G. Brandes) of seasonal dimorphism occurring in tropical and subtropical regions, among which were instances where one seasonal form at least assumes a special protective colouring. Hitherto all the cases investigated and experimented on, whether in Europe or North America, had been found referable to the influence of high and low temperatures, and nobody seems to have suspected the occurrence of similar seasonal variation in hot countries; but, as Mr. L. de Nicéville, Mr. W. Doherty, and other observers have pointed out, and as Weismann was apt to recognise, the alternation of wet and dry seasons is as actively inciting an agent in the production of seasonal dimorphism in many parts of the tropics, as that of hot and cold ones is in the temperate latitudes.

I must confess that I shared in the prevalent erroneous opinion that seasonal dimorphism was not to be looked for in countries without summer and winter seasons of greatly differing temperatures; and no doubt this was mainly due to my never having resided for any length of time in a region where the rainy season is the warmer and the dry one the cooler. In the south-west of the Cape Colony, where I was stationed, exactly opposite conditions prevail, and in the rainy winter, scarcely a dozen species of butterflies appear, and none of them presents any marked difference from the dry summer specimens of the same species. I was thus unprepared to attach due value to the suggestion, by my friend, Mr. W. D. Gooch, as early as the year 1877, of the occurrence of differing seasonal forms of butterflies in Natal, or to the opinion to the same effect given by Mr. A. J. Spiller in 1880 (*Entomologist*, vol. xiii. p. 3). I believe this communication of Mr. Spiller's to have been the first published information of the apparent occurrence of seasonal dimorphism in the warmer parts of the world; and the four cases which he specially notices (in the genera *Anthocharis* [= *Teracolus*], *Pieris*, *Mycalesis*, and *Hypanis*) are undoubtedly true ones. Mr. Gooch (*op. cit.*, pp. 226 and 273) published his concurrence in the main with Mr. Spiller's view, but at the same time mentioned that, in the only two attempts he made to test the matter, by rearing *Teracolus omphale* and *Pieris severina*, he found no difference between the winter and summer broods, both belonging to the theoretical winter form with reduced black markings.

It was in 1885 that Mr. L. de Nicéville, the well-known authority on Indian butterflies, published[1] a notice of apparent seasonal dimorphism in several species of Calcutta *Satyrinae* of the genera *Mycalesis*, *Ypthima*, and *Melanitis*—the wet-season form presenting distinct ocellated spots on the underside, and the dry-season form being without those markings. He suggested as a possible explanation, that while the conspicuously marked wet-season form is concealed by the dense vegetation, the dry-season non-ocellated form had in the scantily-clothed jungle found protection by the gradual loss through natural selection of the conspicuous markings. Mr. de Nicéville's specimens illustrating his paper were exhibited at a meeting of this Society in February 1885, but his view did not meet with much acceptance among the members present, nor was any alternative explanation of the phenomenon brought forward. He was able, however, in the following year to adduce proof of the correctness of his theory in a memoir [2] giving details of the rearing of one seasonal form from eggs laid by the other in four of the seven cases named by him in his previous paper, viz. *Ypthima hübneri* and *Y. howra*; *Y. philomela* and *Y. marshallii*; *Mycalesis mineus* and *M. indistans*; *Melanitis leda* and *M. ismene*; these pairs consisting respectively of the ocellated wet-season form and non-ocellated dry-season form of each species concerned.

Just previously to the latter notable record of Mr. de Nicéville, Mr. W. Doherty had contributed to the same Journal [3] his four years' observation of seasonal variation while collecting Indian butterflies. He brings to notice that, speaking generally, there were *four* broods annually in that country, viz. two in the wet season and two in the dry season, and that, while there was no perceptible difference between the two broods of the same season, there were often very marked differences between the wet-season broods and the dry-season ones. These differences included size (the wet-season form being usually smaller), the angulation of the wings, and the colouring and ocelli of the underside, and were well illustrated by species of *Junonia*, *Ypthima*, *Mycalesis*, and *Melanitis*. The author remarks that some countries with wet climate do not yield any but wet-season forms,[1] and conversely that some very dry countries produce only dry-season ones, instancing the case of *Junonia almana*, the dry-season form of which alone occurs in Scinde, while its wet-season form (*asterie*) only is met with in Ceylon and Singapore. He is of opinion that De Nicéville's view is strengthened by the fact that the dry-season forms are more or less leaf-like both in shape and in the underside colouring, while no such resemblance is manifested by the wet-season ones, and argues that this points to the greater exposure to danger in the dry season; but he is inclined to think that the eye-like underside markings in the wet season may serve as a protection from the attacks of birds. It is singular that, while this observant collector enumerates no fewer than twenty-three species of Pierinae in his "List," he does not seem to have noticed the occurrence of seasonal dimorphism in the subfamily which is especially fertile in illustrations of it.

In view of the satisfactory evidence afforded by De Nicéville's experiments with Indian Satyrinæ, I could no longer doubt that many hitherto puzzling cases of variation among African butterflies would find their solution in the same way, especially as the dated specimens accessible all pointed to the seasonal character of the varieties. I kept the question constantly before my entomological correspondents in Natal and the other warmer parts of South Africa, and was enabled by their assistance to indicate in 1889 ("South-African Butterflies," iii. pp. 6, 7, 125, and 395, 1889), various extremely probable instances of a corresponding phenomenon among African Satyrinæ and Pierinæ. Among a most interesting collection made by Mr. A. W. Eriksson in tropical South-west Africa, described by me in 1891 (*Proc. Zool. Soc. Lond.*, 1891, pp. 59, 64, 85, 89, 96, 97, and 99), I noted what appeared to be undoubted cases of seasonal dimorphism in species of Acræinæ, Lycænidæ and Pierinæ; and again, in cataloguing Mr. F. C. Selous's Manica butterflies in 1894 (*op. cit.*, 1894, pp. 14, 22, 29, 37, 64, and 67), I showed reason for recognising the prevalence of the same kind of variation, especially pointing out how in the case of *Melanitis leda* all the dated South African examples went to confirm De Nicéville's experience at Calcutta, and what strong similar ground existed for considering the much-discussed variation in the Nymphaline *Hamanumida daedalus* to be seasonal.

An important contribution to the elucidation of the subject was made in 1894 by the late Captain E. Y. Watson in a paper entitled "Notes on the Synonymy of some Species of Indian Pierinæ" (*Journ. Bombay Nat. Hist. Soc.*, viii. p. 489 (1894).

According to this experienced entomologist's observations some species—*Terias hecabe*, for instance—produce successive broods (from four in the cooler to ten or twelve in the warmer districts) throughout the year, and the last alone of the wet-season or dry-season broods respectively yields offspring exhibiting the opposite seasonal form; but it is at the same time pointed out that "in some cases the eggs laid by one female would produce more than one form, according to the state of the atmosphere shortly before the emergence of each individual, which is the period at which it would be chiefly affected." The author calls attention to the fact that "in different parts of the Indian Region, the seasons vary to a certain extent, so that it cannot be laid down that specimens captured in any particular month will belong to any particular form"; he defines, however, roughly the limits of the rainy and dry seasons and states that "the very large majority of specimens obtained during those periods will be wet- and dry-season forms respectively." Emphasis is laid on another important point, viz. that the seasonally dimorphic species present numerous intermediate forms, and that these intermediate forms themselves vary according to the vegetation and rainfall, "so that the extreme of a rainy-season form from a district where the rainfall is great and the vegetation dense, is much more pronounced than the extreme of a rainy-season form from a district with slight rainfall and sparse vegetation; and these differences are even more marked in the dry-season forms." The genera of *Pierinae* dealt with in this paper are *Huphina*, *Appias*, *Ixias*, *Terias*, and *Teracolus*, and seasonal dimorphism is shown to prevail largely in all of them, so that the author feels warranted in materially reducing the number of hitherto admitted species, contending that many of these are palpably founded on mere seasonal variations.

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[1] "List of the Butterflies of Calcutta, &c." (*Journ. Asiat. Soc. Bengal*, liv. pl. ii. p. 39.)

[2] "On the Life-History of certain Calcutta Species of Satyrinae, with special reference to the Seasonal Dimorphism alleged to occur in them." (*Op. cit.*, lv. pl. ii. p. 229, 1886.)

[3] "A List of Butterflies taken in Kumaon." (*Journ. Asiat. Soc. Bengal*, lv., pt. ii. p. 107.)

[1] Mr. de Nicéville has recorded (*Journ. Asiat. Soc. Bengal*, lxiv., pt. ii. p. 362, 1895) that in N.E. Sumatra rain falls in every month of the year, and it is rare for a week to pass without a shower, and that consequently there are no dry-season forms of butterflies to be found there, with the solitary exception of the dry-season form of *Melanitis leda*, which (as in Java) prevails all the year round as commonly as the wet-season form.

In 1895, I had the pleasure of receiving from a valued friend and correspondent in Natal, Mr. Cecil N. Barker, the MS. of an interesting paper he had drawn up, from many years' field observations, on the seasonal variation of butterflies in that colony and the adjacent territories. This paper, which was published the same year,[1] proceeds on much the same lines as that of Captain Watson's just noticed, but, instead of being confined to the Pierinæ, traces the occurrence of the phenomenon throughout the suborder, indicating the following cases, viz. Acræinæ 1 (in *Acraea*); Satyrinæ 2 (in *Mycalesis*); Nymphalinæ 9 (1 each in *Atella*, *Junonia*, *Hypanis*, *Hamanumida* and *Charaxes*, and 2 each in *Precis* and *Crenis*); Lycænidæ 3 (in *Lycaena*); and Pierinæ 20 (9 in *Teracolus*, 4 in *Pieris*, 3 each in *Eronia* and *Terias*, and 1 in *Herpaenia*). In many of these thirty-six cases the seasonal differences and the occurrence of intermediate specimens about the change of season are carefully described; and several instances are recorded of the pairing of *Pieris gidica* with *P. abyssinica* or with intermediate examples. Mr. Barker's observations were decidedly in support of my own published opinion as to the seasonal dimorphism of *Hamanumida daedalus*, *Herpaenia eriphia*, *Teracolus regina*, *T. speciosus*, *Pieris pigea*, *P. gidica*, *Eronia cleodora*, and *E. leda*.

Mr. Barker's paper was soon followed by one of equal interest[2] contributed to our *Transactions* by Mr. G. A. K. Marshall, who has a most wide and intimate knowledge of butterfly-life south of the Zambesi. Mr. Marshall, after expressing his concurrence with Mr. Barker's opinions on the subject, proceeds to criticise with justice Dr. A. G. Butler's rather random suggestion (*Trans. Ent. Soc. Lond.* 1895, p. 519) that in the Acræinæ the presence of a broad apical black patch on the forewings indicates a wet-season form, proving this idea to be wholly untenable, at any rate in three of the five cases advanced by Dr. Butler. He goes on to indicate the signs of seasonal variation in nine species of *Acraea*, and notably in the Mashunaland *A. halali*, where both sexes vary strongly, and unlike the other known cases in the genus, have the black spots larger in the dry-season than in the wet-season form. To the numerous instances given by Barker he adds two more in *Mycalesis* and eight more in *Precis*. The latter are shown to offer a beautiful series of gradations in dimorphism, from the four species *P. natalica*, *P. elgiva*, *P. tugela* and *P. artaxia*, where—in addition to larger size and more falcate forewings—the dry-season change is almost limited to the dull withered-leaf colour and marking of the underside; then to the two species *P. ceryne* and *P. archesia*, where the upperside as well presents considerable alteration both in colour and marking; and finally, to the species *P. simia* and *P. octavia-natalensis*, where the suggested respective dry-season forms *P. cuama* and *P. sesamus* present such extreme disparity in the aspect of both upper and under sides as to render it almost incredible that they can belong to the same species as the two wet-season forms in question.

The actual rearing of the dry-season form of *Terias zoe* from eggs laid by the latter, and its proving to be (as had long been anticipated) the butterfly known as *T. brigitta*, is recorded in this paper on the authority of that practised collector and observer, my friend Mr. J. M. Hutchinson, of Estcourt in Natal; and early in 1897, Mr. Marshall, writing from that locality, informed me that he had succeeded in rearing three specimens of *Teracolus auxo*, a wet-season form, from eggs laid by *T. topha*, a dry-season butterfly. In each of these two Pierine cases the close relationship of the seasonal forms was so manifest, that all the circumstances of their occurrence led one to expect the species-identity to be proved before very long; but it was otherwise in the case of *Precis octavia-natalensis* and *P. sesamus*, notwithstanding the significant facts—very close resemblance in both larvæ and pupæ, occasional pairing of the two forms, and the existence of various intermediate examples—which favoured a similar conclusion. Thus it was with no ordinary interest that I received from Prof. Poulton Mr. Marshall's announcement, in a letter dated June 1898, that in three cases he had bred *P. sesamus* from the eggs laid by *P. octavia-natalensis*, and that I saw the actual specimens of parent and offspring in two of the three cases, which had been sent to the Hope Department of the Oxford University Museum. An excellent account by Mr. Marshall of what he rightly describes as "the most remarkable instance of seasonal variation as yet known" was published in July last.[1] What makes the case so striking is not alone the very great difference of the upperside—deep salmon-red with black borders and spots in *octavia-natalensis*, and violaceous-blue streaked with black, and a continuous series of salmon-red spots in *sesamus*—but that of the underside also—almost the same as the upperside, but pinker in *octavia-natalensis*, and very dark greenish-bronze with black streaks in *sesamus*. Owing to the latter disparity nothing could be more different than the appearance of the two forms when at rest, *octavia-natalensis* being very conspicuous, while *sesamus* is well concealed;[2] and this wide divergence is associated with the differing haunts and habits of the two forms. Mr. Marshall seems inclined to the view that the wet-season form *octavia-natalensis* is the older one, and that the dry-season form *sesamus*, with its distinctly protective underside, may be the result of greater persecution—in the scarcity of insects of other orders—during that season. On the other hand, he suggests the possibility of the wet-season *natalensis*-form being in process of modification in mimicry of the prevalent red black-spotted *Acraeae* of the same region, in which case *sesamus* would have to be taken as the older form. I consider the latter to be more likely than the former view, seeing how much less *sesamus* has diverged than *octavia-natalensis* from the general pattern of the genus *Precis*.[3]

A noteworthy fact in Mr. Marshall's experience in this case was that, while in the second instance recorded he reared an example of *sesamus* from an egg laid by *octavia-natalensis*, he also obtained, only five days later, from another egg laid by the same mother, on the same day, a pure *octavia-natalensis*. He expressly states that the two larvæ from which these amazingly different butterflies resulted were reared from the egg under precisely similar conditions; and he adds that not a few similar instances had come under his notice. This is sufficiently remarkable, but it by no means exhibits the apparent extreme of variation among the offspring of one mother; for Mr. de Nicéville (in a letter of June 13 last) assures me that in India "at the change of the season, in one brood, from one batch of eggs laid by one female, you sometimes get both seasonal forms and all intermediate ones."[4] Such cases, like those of more or less complete resistance to altered temperature, so frequent in the experiments of Weismann and others, point very clearly to the operation of some other factor than the degree of humidity, or of temperature; but it must be admitted that we are as yet quite in obscurity as to its actual nature, and that our investigations into seasonal dimorphism must be far more systematically and thoroughly prosecuted before conclusions of a satisfactory character can be arrived at.

While the observations already on record, to which I have drawn attention above, render it beyond question that seasonal dimorphism is of world-wide prevalence, it is at the same time surprising—considering the great and increasing study devoted to exotic butterflies of late years—that so very little is definitely known of the actual range and conditions of its occurrence beyond European limits. So far as the Palæarctic Region is concerned we are indebted to Standfuss[1] for a comprehensive list of the cases recognised, distinguishing between those where the seasonal disparity is so marked as to have led to the bestowal of distinct names on the two forms, and those where the disparity is less and no second name has been given. In the former category there are 23 cases (17 in Butterflies and 6 in Moths), and in the latter 15 (14 in Butterflies and 1 in Moths), making in all 38 cases, viz. 31 in Butterflies and 7 in Moths. The butterflies comprised in the more marked category include 1 case in Satyrinæ, 2 cases in Nymphalinæ, 5 in Lycænidæ, 6 in Pierinæ, and 3 in Papilioninæ; while those in the less marked category are three cases in Satyrinæ, 3 in Nymphalinæ, 3 in Lycænidæ, and 5 in Pierinæ, so that taking the totals of both categories in their order of numerical importance we have 11 cases in Pierinæ, 8 in Lycænidæ, 5 in Nymphalinæ, 4 in Satyrinæ, and 3 in Papilioninæ. The moths are ranked in the more marked category with the exception of a Liparid (*Dasychira abietis*); they are two in the Bombycidæ and four Geometers. The number of known cases in the Palæarctic Region thus appears to be very small, when contrasted with the very large number of species of the groups to which they belong ascertained to inhabit the region; but it may be observed that a considerable proportion of them must be of greatly extended occurrence and very ancient standing, Pryer[2] noting no fewer than six of them in Japan (besides three additional cases in local species); and Dr. A. Fritze[3] further recording in the same country the case of *Araschnia levana* (var. *burejana*).

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[1] "Notes on Seasonal Dimorphism of Rhopalocera in Natal.' (*Trans. Ent. Soc. Lond.*, 1895, p. 413.)

[2] "Notes on Seasonal Dimorphism in South African Butterflies." (*Op. cit.*, 1896, p. 551.)

[1] See "Seasonal Dimorphism in Butterflies of the Genus *Precis*, Doubl." (*Ann. and Mag. Nat. Hist.* (7), ii. p. 30 (1898).

[2] The rarely-occurring intermediate examples, as I have pointed out ("South Afr. Butt.," i. pp. 230, 231, and 233, 1887), exhibit a complete gradation as respects both upperside and underside.

[3] The only other species of *Precis* of the *octavia* pattern and colouring is *P. simia* (considered by Mr. Marshall to be the wet-season form of the dry-season *P. cuama*), and this species may possibly also be mimetic of the *Acraeae*.

[4] It would be of the very greatest service to these inquiries if such a series as this, the offspring of one mother, could be preserved in its entirety, together with a full record of all the conditions bearing on the case. Mr. de Nicéville does not mention the actual species to which his remark applies.

When we turn to the great tropical and subtropical regions, where butterfly life finds its fullest and most varied development, it is almost disheartening to find how extremely little has been done in the observation of this apparently prominent feature of seasonal variation. With the exception of India in the Oriental Region, and South Africa in the Ethiopian Region, none of the hot or warmer countries have hitherto received the slightest investigation as regards this particular subject of biological inquiry. I can find no record of any observations in East or West Africa, in Australia, or in Central and South America. Feeling especially the deplorable lack of information from that paradise of butterflies, the Neotropical Region, I consulted Dr. F. A. Dixey with the view of ascertaining whether the Pierinæ—the group which he has made so emphatically his own, and which in the Old World has yielded more cases of seasonal dimorphism than any other—offered any instances of the kind in Central or South America. He most obligingly brought together, in the Hope Department of the Oxford University Museum, a series of Neotropical species of *Callidryas*, all of which included forms corresponding in character with the seasonal varieties occurring among their Old-World congeners and allies, viz. a larger form, of deep or rich colouring with the underside freckling and markings strongly expressed; a smaller form, of paler colouring, with the underside freckling and markings very faint or altogether absent; and, in addition to these, specimens holding an intermediate position between them as regards the characters mentioned. Dr. Dixey exhibited this series (with some additions and substitutions) at the Society's meeting on December 7, and explained that, in order to meet the possible objection that the variations in question pointed to *local* forms, he had been careful in the case of each species to select examples from the same locality. The species concerned were *C. rurina* (Mexico), *C. neocypris* (South Paraguay), *C. argante* (Brazil), *C. agarithe* (Mexico), *C. sennae* (Guatemala and Brazil), and *C. philea* (Guatemala). There was no sufficient evidence as to the seasons of appearance of these variations, only seven examples (four *C. argante* and three *C. sennae*) in the whole series bearing dates of capture; but the nature of them, and the parallelism with which they were displayed by each of the six species, were such as to leave little doubt of their being seasonal.

I am further indebted to Dr. Dixey for the first indication of the occurrence of seasonal dimorphism in Australia, afforded by the Old-World section (*Catopsilia*) of the same genus *Callidryas*. In one species, *C. gorgophone*, from Melville Island and Queensland, gradations are found quite in correspondence with those observed in both Indian and Neotropical species; and the same phases are even more completely illustrated in a fine series of Brisbane examples of the well-known Oriental *C. crocale*, which lends some probability to Dr. Dixey's suspicion that *C. crocale* and *C. pomona* (including *C. catilla*) will prove to be seasonal forms of one species.[1]

In bringing to a close this attempt to give a general survey of what has been published on the subject, I purposely abstain from indulging in any speculative disquisition on my own part, because, however attractive to myself such a course might be, I very much doubt if, in the present very restricted bounds of our knowledge, it would prove of any service to the Society. To generalise or to speculate to any good purpose demands a considerable body of well-ascertained fact as a basis, and this—as my remarks have shown—is precisely what is wanting in the present instance, notwithstanding the labours of the entomologists of distinction to whom reference has been made. While fully recognising that the artificial-temperature experiments noted above have been designed and conducted with a skill and thoroughness truly admirable so far as certain species of Palæarctic and Nearctic Lepidoptera are concerned, it cannot at the same time be denied that even in Europe very little has been done to ascertain all the natural conditions under which seasonal dimorphism occurs, or to what extent it is adaptive to the environment; and when we turn to the wide tropical and subtropical regions, it is obvious that we stand upon merely the threshold of inquiry. We have, indeed, from these regions—thanks to such capable observers as De Nicéville and Marshall—some valid experimental evidence to guide us, but this must be very greatly added to, and the life-history of the dimorphic species be worked out from many different directions, before we can hope to approach to a clear comprehension of the complex problem now presented by the extraordinarily impressionable and mutable lepidopterous organism. In studying the cases under notice, it is impossible not to recognise that the most diverse influences are at work—indications of protective and mimetic adaptation, and of sexual selection as well, being combined or contrasted with the effects of varying temperatures and degrees of atmospheric humidity, and with distinct tendencies in the direction of reversion to ancestral characters.

The investigation is one to tax the insight and resource of the ablest and most zealous naturalists, and demands unremitting and most exact observation and record, with carefully controlled breeding from the ova for many successive generations, during a considerable series of years. I am as fully persuaded now as I was on the occasion of my last year's address, that such researches as these can never be satisfactorily prosecuted, and still less brought to any interpretation of permanent scientific value, without the establishment in tropical countries of fitly equipped biological stations for the special observation and study, under as natural conditions as possible, of the surrounding terrestrial fauna. It is unnecessary to dwell upon the manifest advantages attendant on well-directed work pursued steadily and continuously in such a zoological observatory, planted in the very midst of the abounding forms of tropical life, or to do more than mention the exceptionally favourable opportunities for discovery that would thus be afforded. In conclusion, therefore, I will simply express my firm conviction that from a few well-organised stations of this kind, on carefully chosen sites in the four great tropical regions, science would gain more in ten years than from the casual and incomplete observations of ordinary collectors and travellers for the next half-century.

THE PROGRESS OF TECHNICAL EDUCATION.

THE eleventh annual report of the National Association for the Promotion of Technical and Secondary Education is filled with details concerning the systemisation and extension of educational work during last year. A few extracts from the report will show that satisfactory progress was made.

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[1] "Handbuch der Paläarktischen Gross-Schmetterlinge für Forscher und Sammler," ed. 1896, p. 229.

[2] "Rhopalocera Nihonica: a Description of the Butterflies of Japan," 1886–88. The species named are *Papilio machaon*, *P. xuthus*, *Pieris napi*, *Colias hyale*, *Vanessa C.-album*, and *Polyommatus phlaeas*.

[3] *Zool. Anzeiger*, 1890, p. 12. Transl. in *Ann. and Mag. Nat. Hist.* 6), v. p. 200 (1890).

[1] *C. crocale* is an extremely variable and very widely distributed butterfly. Mr. de Nicéville (*Gazetteer of Sikkim*, 1894, p. 166; and *Journ. Asiat. Soc. Bengal*, lxiv. ii. p. 490, 1895) considers that *C. catilla* cannot be held a distinct species from *C. crocale*, all the supposed distinctive characters proving quite inconstant, and breaking down when large numbers of specimens are compared. But he does not think seasonal dimorphism comes into play here, "the innumerable varieties which are found in both sexes occurring at all times."